Floquet-Bloch theory and topology in periodically driven lattices

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Since the recent discovery of a new class of materials, the Topological Insulators, the search for topological transitions in condensed matter has become a prior task. Recently, the idea of inducing bands inversion in HgTe quantum wells by means of an ac potential was proposed [1] . In the present work we propose a theoretical formalism to describe topological phase transitions in systems which possess both spatial and time periodicities, i.e., periodic lattices driven by periodic time dependent electric fields. Our formalism allows to obtain effective hamiltonians for different driving regimes and to perform a complete topological classification of the system by means of the topological invariants. It is also general in the sense that it is suitable for describing different physical systems with arbitrary spatial dimension under ac fields for any frequency range, i.e., from adiabatic to diabatic or high frequency regimes[2] . We demonstrate that, at low frequencies, the Floquet hamiltonian for a D-dimensional system driven by a time periodic field is equivalent to a hamiltonian of a static system in D+1 dimension. leading to new topological properties which otherwise would be inaccesible. We show as well that different topological phases can be achieved by changing the lattice inter- site hoppings through the tuning of the ac field parameters. We show that the field amplitude controls the renormalization of the system parameters, while the frequency acts analogously to a DC electric field in the extra dimension. In particular, this last property relates the high frequency regime with the existence of Bloch oscillations and Landau-Zener transitions between bands, establishing a direct relation between diabatic regime and localization[3] . We illustrate our formalism with the analysis of an ac driven dimers chain[2] .

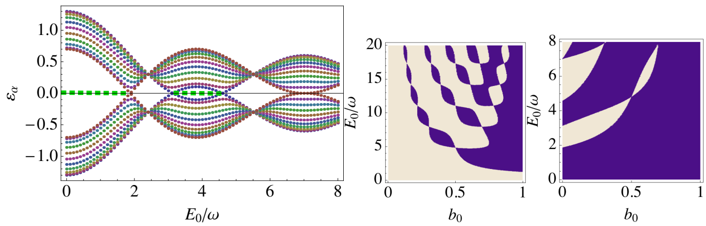

Figure 1: Left: Quasi-energy spectrum vs field amplitude for a dimers chain with hopping amplitudes ratio $\frac{\tau'}{\tau} = 0.3$ in the high frequency regime ($\omega \gg \tau$). Gapless modes in green dotted lines. Right: Phase diagram for the ac driven dimers chain with $\frac{\tau'}{\tau} = 0.3, 2$ (left and right respectively) as a function of the field amplitude and the intra-dimer distance b_0. Dark color means non-zero winding number. Note that non-trivial phases are possible for $\frac{\tau'}{\tau} > 1$ in diference with the undriven case.

*References

[1] Linder et al. , Nature Phys. **7**, 490 (2011).

[2] A. Gómez –León and G. Platero, submitted.

[3] N. Marzari et al., Rev. of Mod. Phys. **84**, 1419 (2012).